UNITIZED VERSUS HAND LOADING OF VAN CONTAINERS FOR EXPORTING FLORIDA GRAPEFRUIT

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UNITIZED VERSUS HAND LOADING OF VAN CONTAINERS FOR EXPORTING FLORIDA GRAPEFRUIT

By William R. Miller,[1] Lawrence A. Risse,[2] Ben M. Hillebrand,[2] Thomas Moffitt,[1] and William R. Black[3]

ABSTRACT

Boxed grapefruit were shipped in refrigerated van containers from Florida to the Netherlands to determine if unitized slipsheet loads would be as stable and maintain grapefruit temperature and condition as well as three conventional hand-stacked loading patterns. In general, the slipsheet loads were as good as the seven-by-six airflow and modified seven-by-six airflow loads. In these loads, it took about the same time to reduce grapefruit temperature at loading to the desired transit temperature, and grapefruit temperature was maintained as desired during shipment. The slipsheet loads were the most stable and had the least box damage, the modified seven-by-six airflow loads ranked second, the seven-by-six airflow loads ranked third, and the six-by-four modified bonded blocks were unsatisfactory. In all loading patterns, damage to the fiberboard boxes was greatest in the rear of the van containers and in the bottom layers. At unloading, there was no significant difference in grapefruit condition among loading patterns. **KEYWORDS: grapefruit exporting, perishables handling, refrigerated van containers, slipsheet loading, stacking patterns, unitized loading.**

INTRODUCTION

Paralleling increased exports of Florida grapefruit to Europe over the past decade has been an increased use of refrigerated van containers to preserve grapefruit quality during shipment. At the same time, Florida packinghouses have been converting to automated systems in which boxes of grapefruit are stacked on a thin fiberboard slipsheet that can be handled as a unit in warehouse and shipping operations.

Although slipsheet loading is of no particular interest to European importers (they usually do not have the equipment needed to handle slipsheets), the method saves the shipper time and money. First, loading and unloading time is reduced, and this also means that the grapefruit are exposed to ambient temperature for a shorter time. Second, boxes need less individual handling, which also reduces damage to the fruit. Third, the need to train and supervise laborers in the loading of van containers by hand is eliminated.

Shippers repeatedly ask, however, Can unitized slipsheet loads be successfully shipped in van containers to export markets? To answer that question, we monitored several unitized and conventionally hand-stacked loads shipped from Florida to Europe.

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TEST METHODS

During the 1973–74 and 1974–75 shipping seasons, 18 refrigerated van containers of Florida grapefruit were monitored in 8 shipments to compare the performance of 3 hand-stacked loading patterns and unitized slipsheet loads. The three hand-stacked loading patterns, described in following sections, were six-by-four modified bonded block, modified seven-by-six airflow, and seven-by-six airflow. Table 1 shows the test arrangement. To make the results comparable within a shipment, the same packinghouse loaded all grapefruit, which were of similar quality and condition, for that shipment.

All grapefruit were place-packed in ⅘-bushel, full-telescope, corrugated fiberboard boxes, corrugated container No. 6488. The boxes had 350-pound test fiberboard bodies and 200-pound test fiberboard covers. The inside dimensions of this box are 17 by 10⅝ by 9⅝ inches. Two slotted vents are on each side of the box.

Thirty-five- and forty-foot van containers were used for shipping. The 35-foot containers (which were used exclusively in 1973–74) measured 387 by 87 by 88 inches, inside dimensions (length, width, height), and the 40-foot containers measured 454 by 88 by 86

TABLE 1.—*Loading patterns tested in* ǫ *shipments of Florida grapefruit*

Shipment number	Loading pattern[1]			
	Slipsheet	6×4 Modified bonded block	Modified 7×6 airflow	7 Ai
1973–74				
1*	X	X	X	
2*	X	X	X	
3*	X	0	0	
1974–75				
4*	X	0	X	
5**	X	0	0	
6*	X	0	X	
7**	X	0	0	
8*	X	0	X	

* 35-foot van container used.
** 40-foot van container used.
[1] X, tested; 0, not tested.

inches. Because of the difference in the len[g] of the containers, the citrus boxes were stac[k] six or seven layers high to achieve a payl[o] of approximately 950 boxes.

The van containers were loaded with [t] boxed grapefruit at various packinghouses a[nd] trucked to the port of embarkation for saili[ng] to Rotterdam. Refrigerated air to the car[go] (called cargo air in this report) was deliver

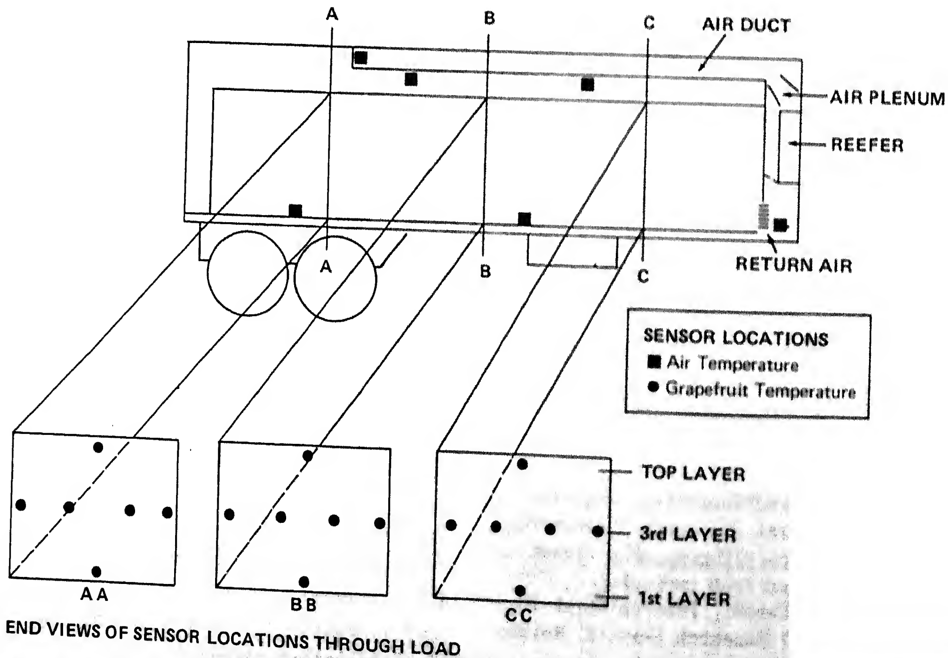
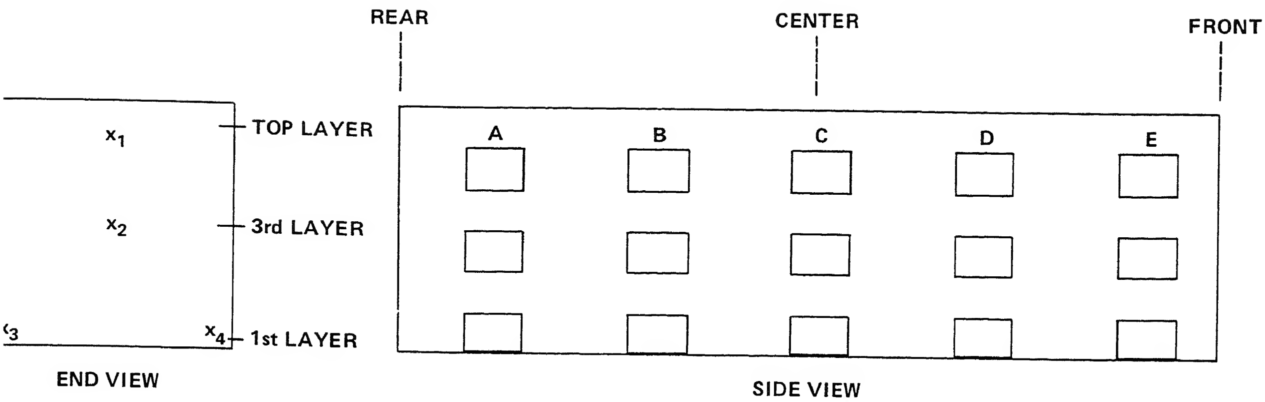


FIGURE 1.—Approximate locations of 24 sensors used for monitoring cargo-air and grapefruit temperatures.



URE 2.—Location of 20 sample boxes (A–E) placed in each van container for evaluation of fruit condition at destination (1974–75).

ough ducts attached to the container ceilings l returned at the front behind the bulkhead. e thermostat in all shipments was set at ' or 50° F except for shipment 3, in which thermostat was inexplicably changed to F after about 10 days.

During shipment, internal grapefruit temature and cargo-air temperature were nitored manually with thermocouples or with automatic temperature recorder and thermor sensors. Eighteen sensing probes were ced throughout each load to measure grapeit temperatures, and six sensors monitored air temperatures (fig. 1). Temperatures re recorded manually at 8- or 12-hour inters when possible. When the automatic recorddevice was used, temperatures were orded at 2-hour intervals.

At Rotterdam, the van containers were unled for local delivery or put aboard a shuttle sel for transport to Le Havre, France. The containers were taken by motortruck from port to central market warehouses for ribution to various wholesalers. The elapsed isit time from the Florida packinghouses he receivers was between 15 and 18 days.

At their destinations, all shipments were cked for box damage and disarray or shiftof boxes. In the 1974–75 shipments, the lition of the grapefruit was evaluated also criteria established in previous research.[4] cifically, 20 sample boxes, which had been ced with grapefruit from the same grove and placed throughout each load as shown in figure 2, were inspected for deformation and decay of fruit. Deformation was scored slight when the flattened surface area of a fruit measured from 1 to 2 inches across, and serious when the flattened surface area measured more than 2 inches. Decay was scored regardless of the size of the affected area.

[4] W. Hale, R. H. Hinds, Jr., and T. Moffitt. 1973. rboard cartons for exporting grapefruit. U.S. Dep. c., Agric. Res. Serv. [Rep.] ARS–S–21, 7 pp.

Unitized Slipsheet Loads

The slipsheet used in Florida for citrus is a 40- by 52-inch fiberboard sheet with a single 4-inch lip on one 40-inch side and a round 11-inch center hole. The corrugated fiberboard is either 250- or 275-pound test stock. Boxes are arranged on a slipsheet nine per layer, and the layers are stacked either six or seven high. In figure 3, note the slight overhang (2½ inches) of the boxes over the 40-inch width. The slipsheet units are placed in the van con-

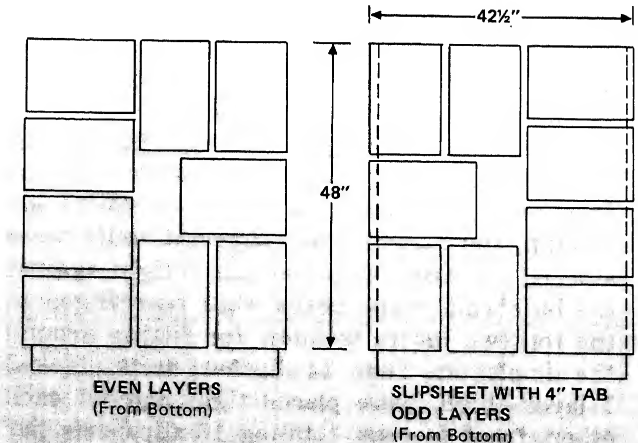


FIGURE 3.—Arrangement of ⅘-bushel citrus boxes on slipsheet.

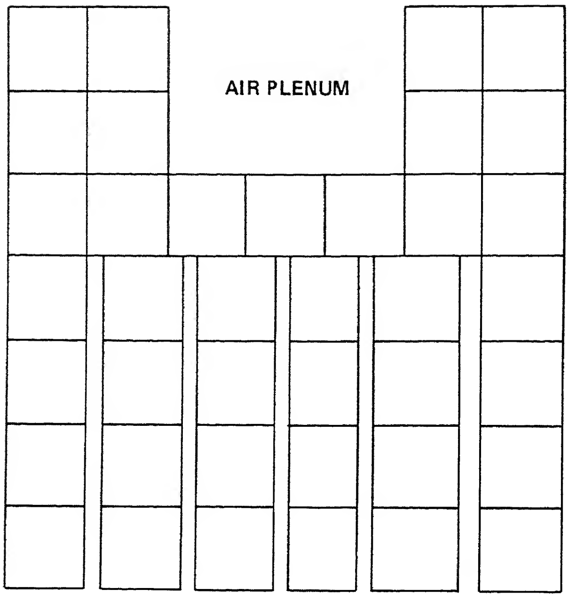


FIGURE 4.—"Header stack" in van containers with an air plenum projecting into cargo area.

tainers with the 40-inch dimension running lengthwise of the vehicle.

In the van containers used in 1973–74, the air plenum projected into the cargo area. The first two stacks of boxes were placed by hand at the front of these containers, against the bulkhead. The forwardmost stack, the "header stack," consisted of 39 boxes. In figure 4, note that the bottom four layers of boxes are stacked squarely on top of each other, six across, with space between the stacks to allow air to return to the refrigeration unit. The second stack consisted of 46 boxes arranged in an alternating 7-by-6 airflow pattern, 7 layers high (fig. 5). Fourteen slipsheet units were then placed tight against the forward units and the container walls. The distance (2 to 3 inches) remaining between the slipsheet units generally disappears as the boxes settle during transit.

The slipsheet loads evaluated during the 1974–75 season did not have header stacks. Instead, in containers with the extended air plenum, the forward two slipsheet units were stacked six layers high and placed tight against the bulkhead. Some boxes were rearranged in the top two layers to allow for fitting around the air plenum. Then, 14 slipsheet units, stacked 7 layers high, were placed tight against each other, front to rear, totaling 16 slipsheets per container. Figure 6 shows such a load in a

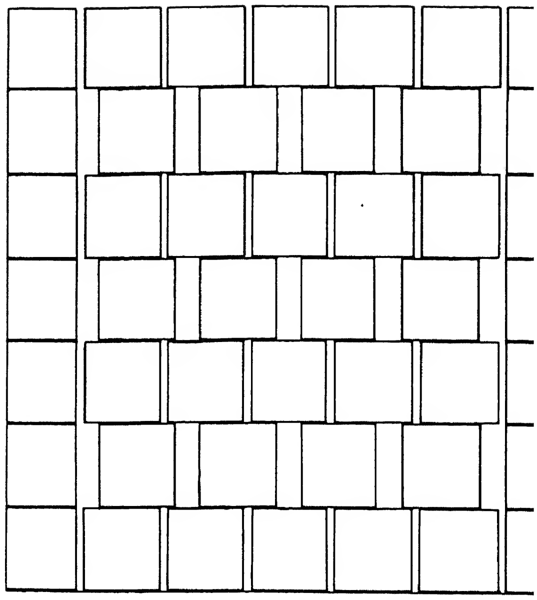


FIGURE 5.—Arrangement of boxes in a seven-l airflow pattern (rear view).

35-foot container. (In the 40-foot contai 18 slipsheet units stacked 6 layers high loaded.)

A wrap of filament tape around the perim of the top two layers of each slipsheet increased stability during handling transit.

Six-by-Four Modified Bonded-Block Lo

The bonded-block pattern was started wi

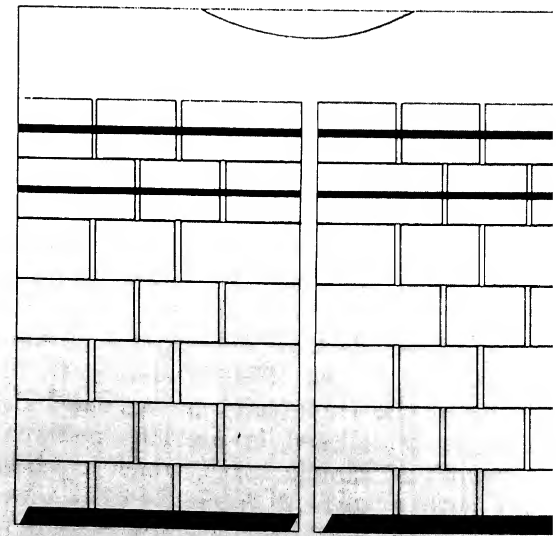


FIGURE 6.—Arrangement of boxes on slipsheets 35-foot van container (rear view).

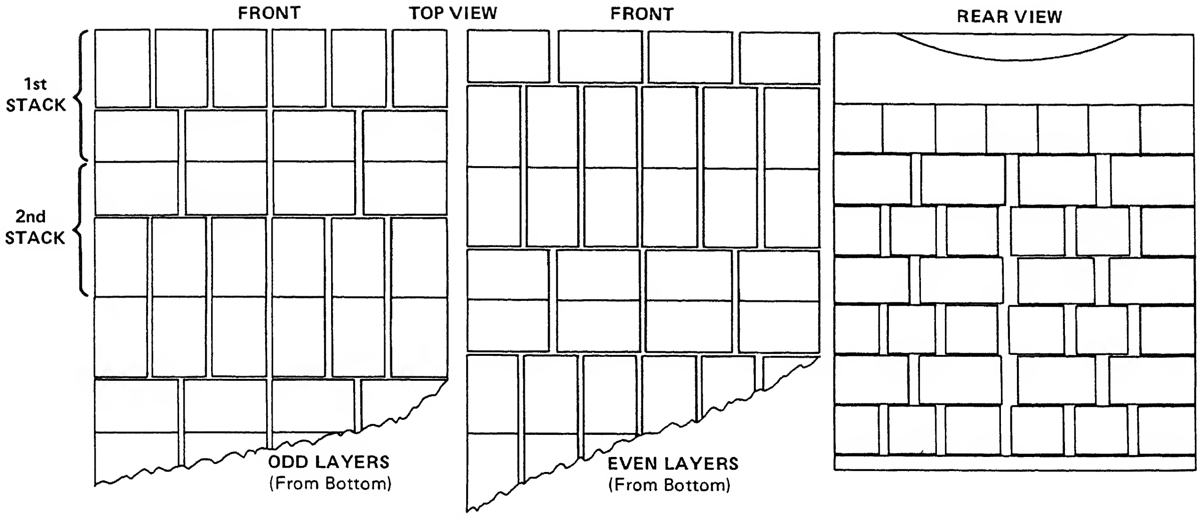


FIGURE 7.—Arrangement of boxes in a six-by-four modified bonded-block pattern.

39-box header stack placed against the bulkhead (fig. 4). The remaining load consisted of 12 stacks with 71 boxes in each stack. The seventh, or top, layer of each stack was arranged seven boxes across instead of six, to give additional crosswise stability.

To have a 950-box payload per van container, 59 additional boxes were placed as "floaters" on the top of the 7 layers. These 59 boxes were placed lengthwise by twos against each container wall. These boxes are not shown in figure 7, which illustrates the bonded-block stacking arrangement.

Generally, a six-by-five modified bonded-block pattern is recommended; however, it cannot be used in van containers because they are too narrow. For a complete discussion of this pattern, refer to Marketing Research Report 715.[5]

Modified Seven-by-Six Airflow Loads

Figure 8 is a rear view of a van container loaded in the modified seven-by-six airflow pattern. On the right sidewall, the boxes (192 in all) were stacked crosswise six layers high in 32 stacks. The remaining boxes were placed lengthwise in a 6/5/6/5/6/6 pattern in 21 stacks. Additional boxes were placed on the top layer along the walls as "floaters" to give the desired payload. This pattern was tested only in the 35-foot containers.

Seven-by-Six Airflow Loads

In the 35-foot van container, 39 boxes were placed in the header stack (fig. 4). The remaining boxes were placed 7/6/7/6/7/6/7 in 20 stacks, yielding a payload of 959 boxes. This stacking pattern is shown in figure 5.

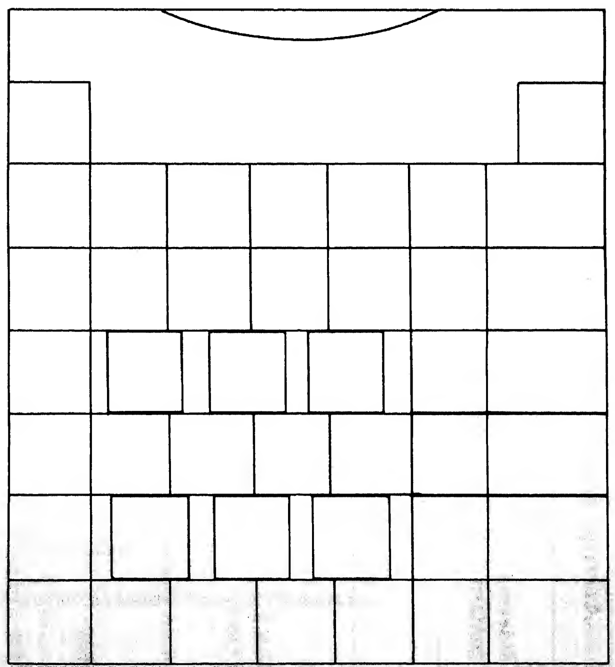


FIGURE 8.—Arrangement of boxes in a modified seven-by-six airflow pattern in van container (rear view).

[5] R. H. Hinds, Jr., and J. K. Robertson. 1965. A better loading pattern for trailer shipment of citrus fruit. U.S. Dep. Agric. Mark. Res. Rep. No. 715, 8 pp.

TABLE 2.—*Average internal temperature of grapefruit during shipment in van containers, by stacking pattern and shipment number*[1]

Stacking pattern	Shipment No.	Thermostat setting (°F)	Average grapefruit temperature (°F)						
			At loading	At selected times after loading					
				48 hours	96 hours	144 hours	192 hours	240 hours	288 hours
Slipsheet	1	50	79 (+29)	57 (+7)	52 (+2)	53 (+3)	54 (+4)	52 (+2)	54 (+4)
	2	47	75 (+28)	61 (+14)	51 (+4)	48 (+1)	50 (+3)	51 (+4)	51 (+4)
	3	50	82 (+32)	60 (+11)	53 (+3)	53 (+3)	53 (+3)	52 (+2)	....
	7	50	74 (+24)	55 (+5)	52 (+2)	53 (+3)	53 (+3)	....	....
	8	47	74 (+27)	53 (+6)	52 (+5)	51 (+4)	51 (+4)	52 (+5)	51 (+4)
Modified 6×4 bonded block.	1	50	82 (+32)	52 (+2)	55 (+5)	52 (+2)	54 (+4)	54 (+4)	54 (+4)
	2	47	79 (+32)	58 (+11)	50 (+3)	50 (+3)	50 (+3)	51 (+4)	51 (+4)
Modified 7×6 airflow	1	50	81 (+31)	59 (+9)	57 (+7)	52 (+2)	55 (+5)	52 (+2)	52 (+2)
	2	47	78 (+31)	59 (+12)	51 (+4)	49 (+3)	50 (+3)	51 (+4)	53 (+6)
	8	47	67 (+20)	52 (+5)	49 (+2)	49 (+2)	49 (+2)	49 (+2)	49 (+2)
7×6 airflow	3	50	80 (+30)	60 (+10)	52 (+2)	52 (+2)	53 (+3)	52 (+2)	....
	7	50	76 (+26)	54 (+4)	53 (+3)	53 (+3)	53 (+3)	54 (+4)	54 (+4)

[1] Numbers in parentheses give the deviation of average pulp temperature from the thermostat setting.

In the 40-foot container, this pattern was loaded 7/6/7/6/7/7 six layers high and 7/6/7/6/7 five layers high. The number of stacks having five or six layers per container depends on the desired box count per load.

RESULTS

Temperatures

Table 2 gives the average internal grapefruit temperatures at selected time intervals during five representative shipments. Figures 9, 10, and 11 depict average grapefruit temperatures in shipments 1, 2, and 3 by loading pattern. The curves were plotted from averages of the 18 simultaneous temperature measurements taken in each grapefruit load during shipment, as explained in "Test Methods." Initial temperatures at loading ranged from 77° to 81° F.

Figure 9 shows average grapefruit temperatures in the slipsheet, modified seven-by-six airflow, and six-by-four bonded-block loads (shipment 1). The air outside the container fluctuated from 86° F at loading to a low of 38° F after 210 hours of transit. The lowering of grapefruit temperatures during the first 68 to 70 hours after loading was quite similar in all loading patterns. The increase in the air temperature outside the containers to 75° F during the same period when grapefruit temperatures were nearing the thermostat setting may have had an effect on grapefruit temperatures, which decreased slowly from that point until stability in temperature occurred. It appears that when outside air temperatures began to fall between the 42- to 54-hour period, grapefruit temperatures increased slightly and then decreased at a slower rate. During the remaining time, average grapefruit temperatures in each stacking pattern fluctuated slightly above the 50° F thermostat setting. Each load was exposed to the same conditions and, regardless of the stacking pattern used, the response to the refrigerated air entering the container was similar. Satisfactory grapefruit temperatures were maintained.

The results obtained during shipment 2 are shown in figure 10. The temperatures of the three patterns were quite similar during the 80 hours it took for grapefruit temperatures to reach the thermostat setting. Grapefruit temperatures in each stacking pattern were quite similar during the remaining transit time.

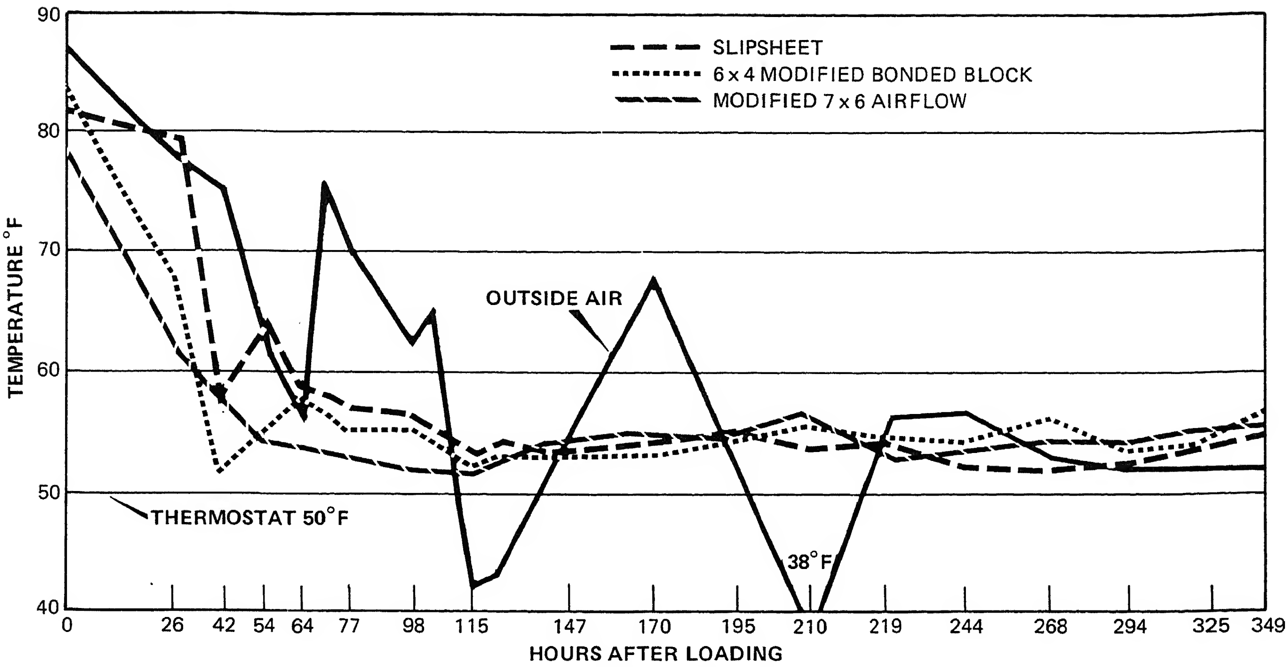


FIGURE 9.—Average grapefruit temperatures during shipment 1.

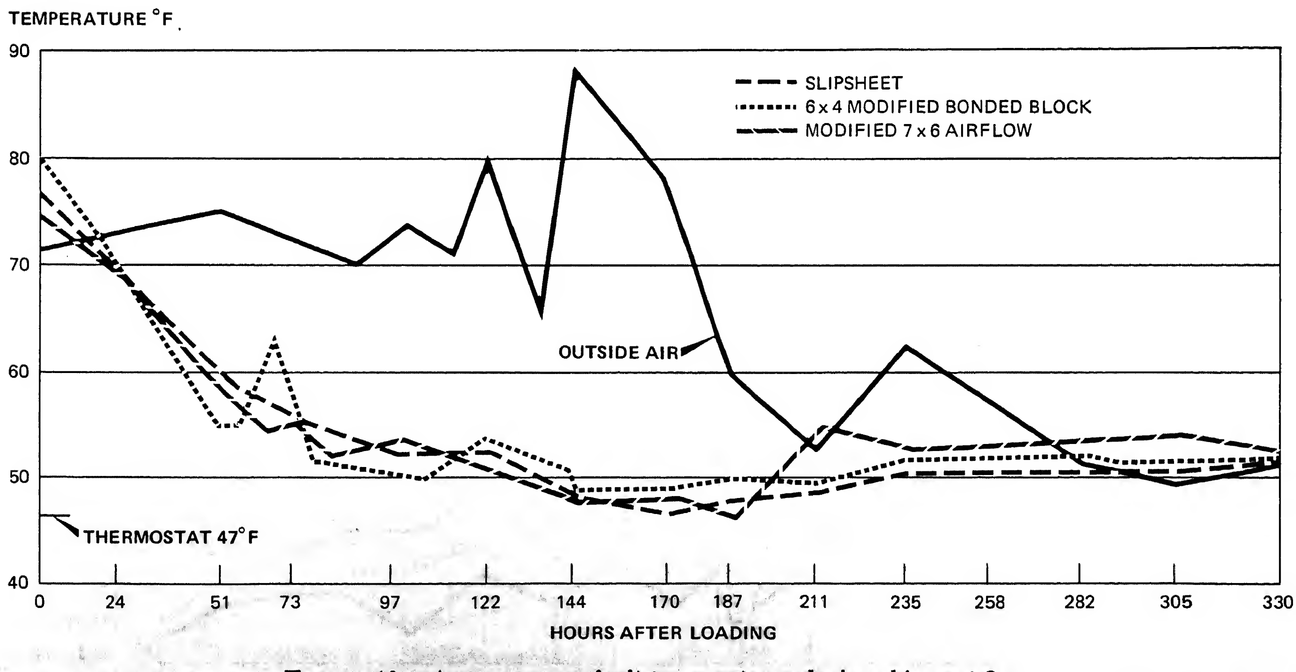


FIGURE 10.—Average grapefruit temperatures during shipment 2.

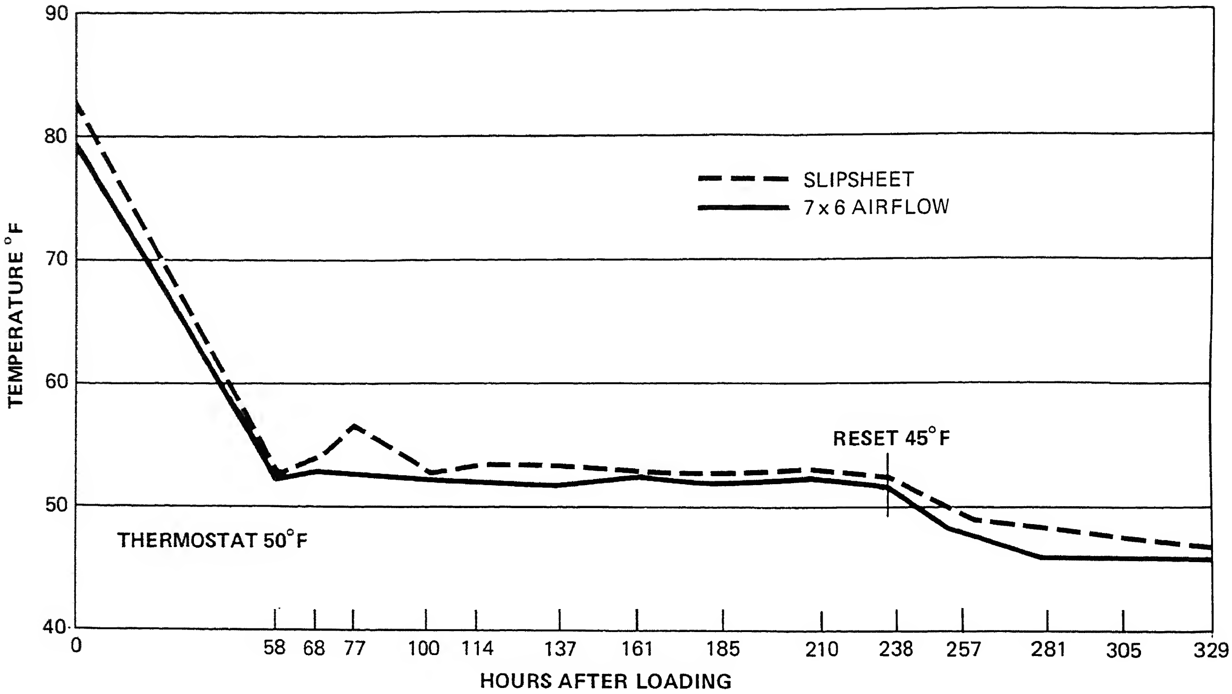


FIGURE 11.—Average grapefruit temperatures during shipment 3.

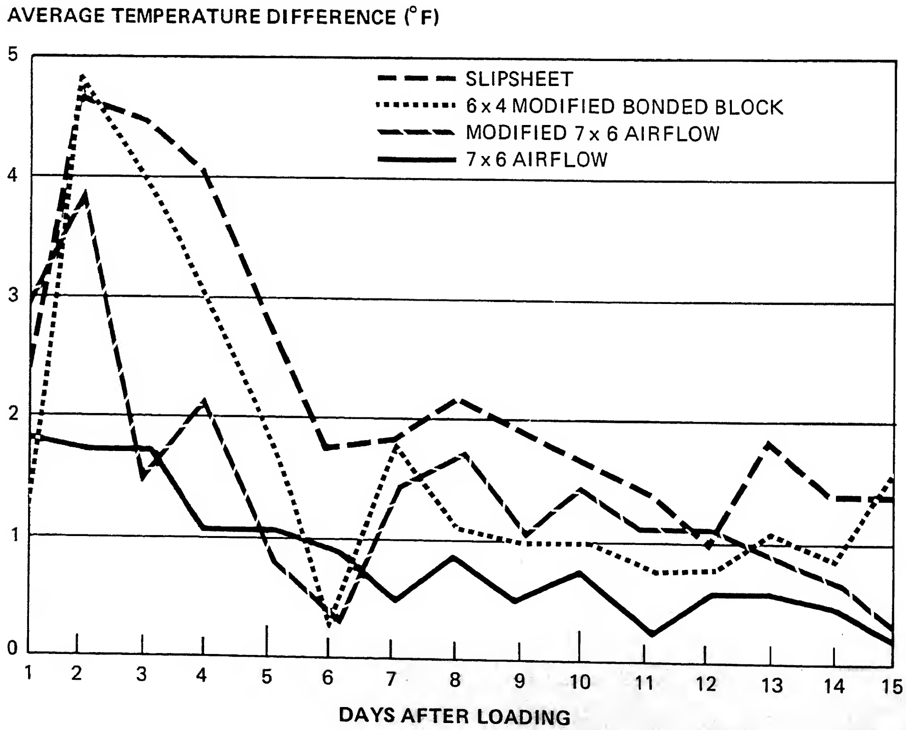


FIGURE 12.—Average differences in grapefruit temperatures between the highest and lowest temperature areas (front, center, rear) within a van container, 1973-74 shipments.

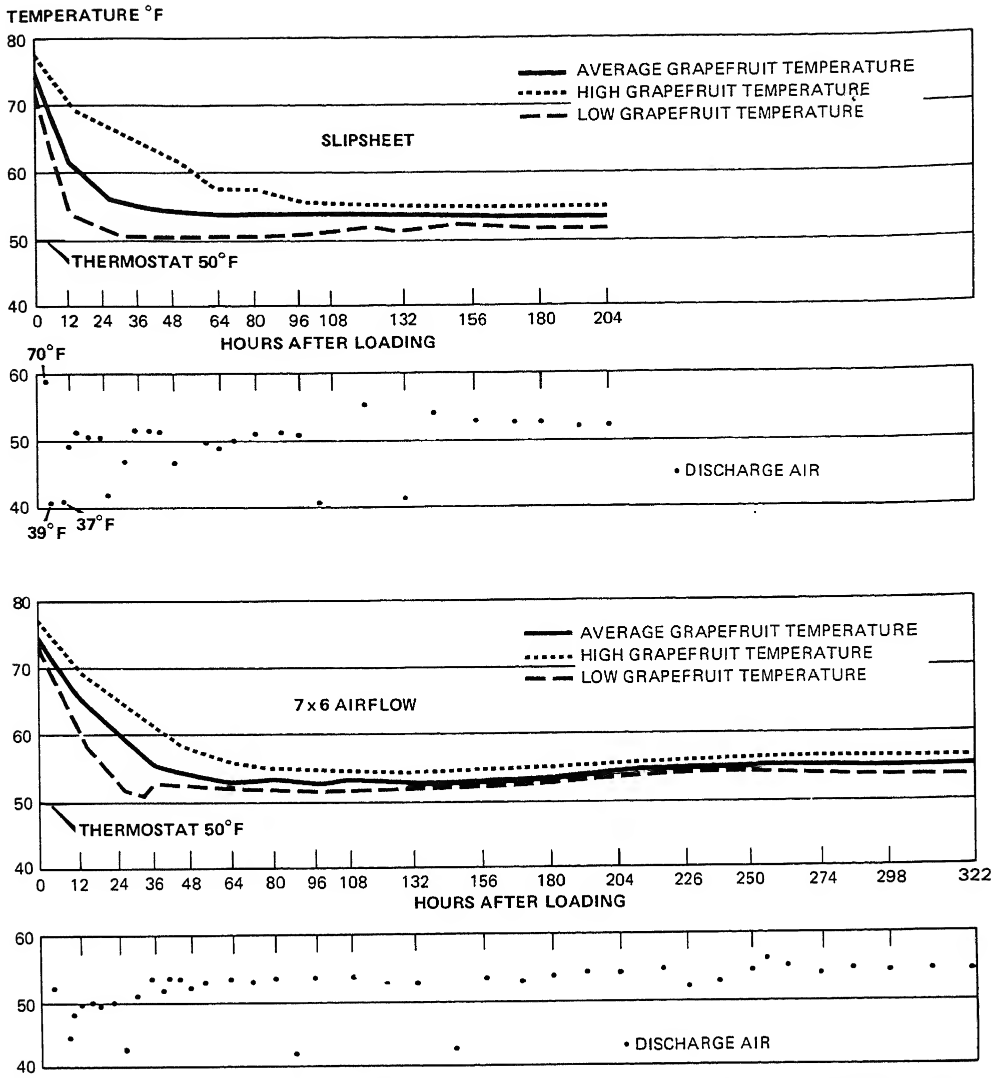


FIGURE 13.—High, low, and average grapefruit temperatures and discharge-air temperatures in a van container, shipment 7.

Figure 11 shows average grapefruit temperatures recorded in shipment 3, in which the slipsheet pattern was compared to the seven-by-six airflow pattern. Grapefruit temperatures were recorded at loading but were not recorded again until approximately 58 hours later. In the slipsheet load, temperatures were slightly higher than in the seven-by-six airflow load, and in both loads they were consistently higher than the 50° F thermostat setting until the thermostats were changed to 45° F after 245 hours in transit. The temperature response of these two loads was similar, and satisfactory grapefruit temperatures were maintained.

Grapefruit temperatures in the 1973–74 shipments were averaged by loading pattern and by

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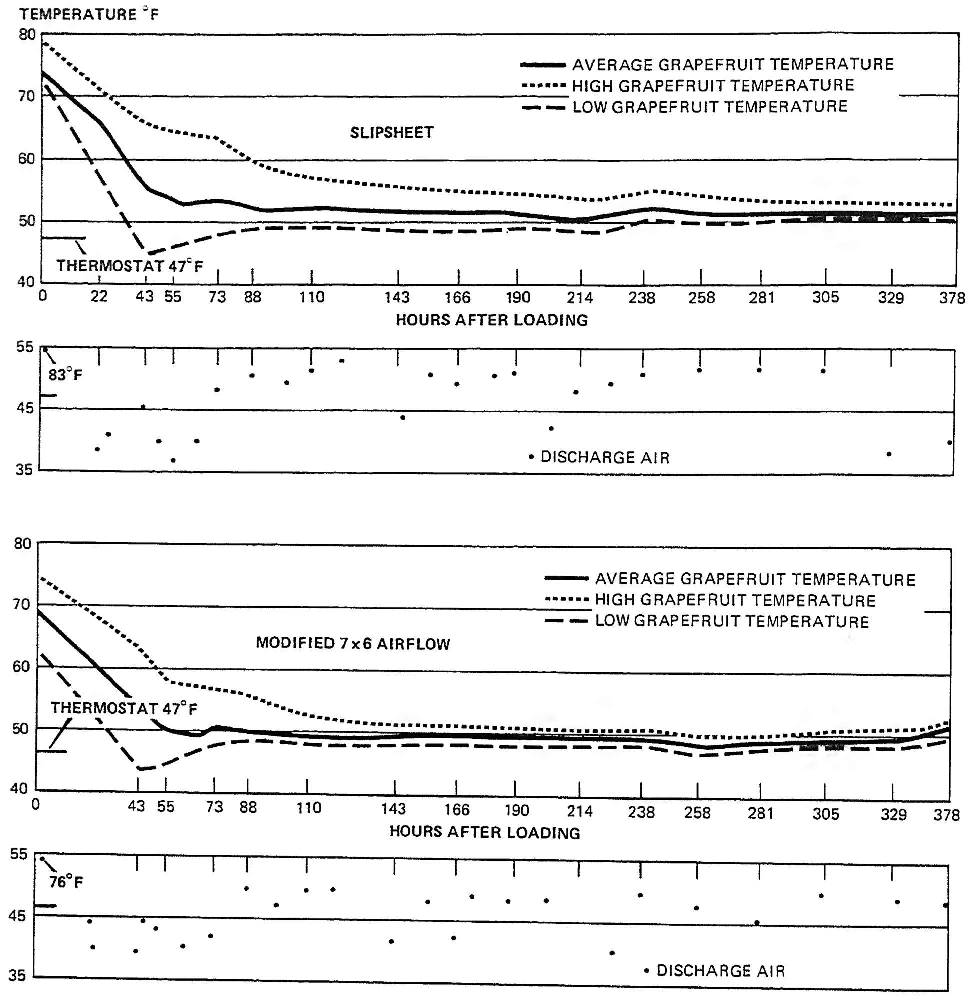

FIGURE 14.—High, low, and average grapefruit temperatures and discharge-air temperatures in a van container, shipment 8.

greatest temperature spread of the stacking patterns tested. After 5 days, all stacking patterns had a temperature spread of less than 2°. During the first 2 days, the slipsheet and bonded-block patterns had a greater temperature spread than the modified seven-by-six airflow or seven-by-six airflow patterns. Although there were some differences in temperature uniformity from loading pattern to loading pattern during the first days of transit, such differences should not have any adverse effect on the arrival and marketing condition of grapefruit.

Figure 13 shows high, low, and average grapefruit temperatures in relation to the temperature of the refrigerated air entering the container (discharge air) in shipment 7. In the slipsheet load, average grapefruit temperatures at loading were about 75° F and decreased to 52° F after about 96 hours; discharge-air temperatures during this period fluctuated near 50° F. In the seven-by-six airflow load, average grapefruit temperatures at loading were about 75° F and decreased to about 56° F after 75 hours; discharge-air temperatures fluctuated near 50° F for approximately 30 hours and then fluctuated between 53° and 55° F. Average grapefruit temperatures in the slipsheet load decreased about 2° lower than those in the seven-by-six airflow pattern between about 65 and 100 hours, probably because of the lower discharge-air temperature for a longer period of time in the slipsheet van container. The difference between single high and low grapefruit temperatures was considerably greater in the slipsheet

pattern than in the seven-by-six airflow pattern, especially during the first few days of transit, when grapefruit temperatures were approaching discharge-air temperature.

Figure 14 shows the same kind of data for shipment 8. In the slipsheet load, average grapefruit temperatures decreased from about 73° to 52° F in approximately 63 hours. After this time, grapefruit temperatures averaged 52° to 53° F. In the modified seven-by-six airflow load, average grapefruit temperatures decreased from about 65° to 49° or 50° F in about 55 hours. Generally, there was a larger spread in the highest and lowest temperatures in the slipsheet pattern than in the modified airflow pattern. This was also observed in shipment 7 and is consistent with the results shown in figure 12 for the 1973–74 shipments, but again, these differences should not adversely affect the arrival condition or marketability of grapefruit.

Box Damage

The most noticeable damage to the corrugated fiberboard citrus boxes during shipment occurred in the lower layers of the rear stacks in all stacking patterns. Both at the shipping point and destination there were only minor differences in the degree of box damage among loading patterns.

Unitized slipsheet shipments

The unitized shipments on slipsheets had little box damage. Boxes on slipsheets are relatively tightly stacked, and the bottom surface area of any box is in nearly full contact with lower boxes, thus allowing the corner strength of each box to better support its overhead weight. The top two layers of each slipsheet stack were taped with ¾-inch filament tape to increase loading and transit stability. The rear slipsheet units had a tendency to shift toward the rear doors. When excessive space exists between the rear stack and the rear doors, bracing or dunnage should be inserted to minimize shifting.

Airflow shipments

In modified seven-by-six airflow loads, no disarrangement of boxes occurred; slight crushing was observed only in the very bottom layer of the rear stack. The seven-by-six airflow loads arrived with little box disarray. The

TABLE 3.—*Percentage of deformation and decay observed in 20 sample boxes in 40-foot van containers*

Measurement	Shipment 5[1]		Shipment 7[2]		Average for loading pattern, shipments 5 and 7[3]	
	7×6 Airflow	Slipsheet	7×6 Airflow	Slipsheet	7×6 Airflow	Slipsheet
Slight deformation:						
Top layer	5.50	21.25	12.50	10.00	15.74	19.20
Middle layer	15.28	15.83	18.57	23.92		
Bottom layer	18.29	20.83	22.86	23.40		
Average	13.51	19.30	17.97	19.10		
Serious deformation:						
Top layer	0.00	1.66	1.42	0.36	3.36	2.14
Middle layer	2.77	1.66	3.57	3.57		
Bottom layer	6.71	1.66	5.54	3.92		
Average	3.20	1.66	3.51	2.61		
Decay:						
Top layer	0.45	0.42	0.71	0.36	.90	.65
Middle layer	1.39	1.25	1.07	.71		
Bottom layer	.93	.83	.89	.36		
Average	.92	.83	.89	.47		

[1] Loaded at packinghouse Nov. 14, 1974.
[2] Loaded at packinghouse Feb. 5, 1975.
[3] Analysis of variance showed no significant difference in slight and serious deformation and decay by stacking pattern at the 5% level in shipments 5 and 7.

TABLE 4.—*Percentage of deformation and decay observed in 20 sample boxes in 35-foot van containers*

Measurement	Shipment 4[1]		Shipment 6[2]		Shipment 8[3]		Average for loading pattern shipments 4, 6 and 8[4]	
	Modified 7×6 airflow	Slipsheet	Modified 7×6 airflow	Slipsheet	Modified 7×6 airflow	Slipsheet	Modified 7×6 airflow	Slipsheet
Slight deformation:								
Top layer	20.6	11.3	25.4	18.9	5.0	9.6		
Middle layer	31.0	30.2	38.9	42.5	16.4	23.9		
Bottom layer	31.2	23.4	40.2	33.2	26.8	27.3	26.2	24.5
Average	27.6	21.6	34.8	31.6	16.1	20.3		
Serious deformation:								
Top layer	2.3	3.8	6.4	3.2	1.1	0.0		
Middle layer	13.4	23.6	19.3	25.4	2.9	3.9		
Bottom layer	28.3	42.4	41.1	45.9	5.2	12.1	13.3	17.8
Average	14.7	23.3	22.3	24.8	3.0	5.4		
Decay:								
Top layer	0.0	0.0	0.4	0.4	0.4	0.7		
Middle layer	1.0	.0	1.1	1.1	1.1	1.1		
Bottom layer	.4	.3	.4	.9	1.4	1.6	.7	.7
Average	.5	.1	.6	.8	1.0	1.1		

[1] Loaded at packinghouse Sept. 20, 1974.
[2] Loaded at packinghouse Dec. 3, 1974.
[3] Loaded at packinghouse Mar. 20, 1975.
[4] Analysis of variance showed no significant difference in slight and serious deformation and decay by stacking pattern at the 5% level in shipments 4, 6, and 8.

rearmost boxes in the bottom layers were slightly crushed when stacked seven layers high. Most box damage could be attributed to offsetting of the boxes (see fig. 5), which decreased their capability to support overhead weight. The pattern did perform satisfactorily when it was stacked six layers high in the 40-foot van container.

Six-by-four modified bonded-block shipments

The six-by-four modified bonded-block pattern was least stable because only four boxes could be placed crosswise in the van container, resulting in excessive air channels and misalinement of the boxes. In this pattern a natural split ran lengthwise through the center of the load (fig. 7) which allowed side-to-side shifting during shipment. At destination, boxes in the rear were excessively crushed, and for this reason the pattern was not tested further in 1974–75.

Grapefruit Condition

Tables 3 and 4 list the percentages of slight and serious deformation and decay observed in each shipment in the 1974–75 season. Deformation will vary according to the firmness of the fruit, which is, in turn, determined by ripeness and maturity. Therefore, comparisons can only be made between stacking patterns within a single shipment. There were no significant differences in deformation and decay between loads within a shipment. The amount of decay in these shipments was 1 percent or less; recognizing that any decay is not good, 1 percent or less is commercially acceptable. Deformation is also an undesirable condition that should be decreased or eliminated, if possible, but these tests show that the stacking pattern used will not reduce the incidence of deformation.

CONCLUSIONS

The results of this study indicate that the use of slipsheets for unitizing fiberboard boxes will not significantly affect the arrival condition of Florida grapefruit in van containers at the European market. Grapefruit temperatures will respond to refrigerated air similarly whether the boxes are hand-stacked or loaded

on slipsheets. The length of time required to decrease grapefruit temperature to the thermostat setting will vary for different shipments with the same stacking arrangement because of differences in refrigeration units and air temperatures outside the containers. Except for the six-by-four modified bonded-block loading pattern, which proved to be unsuitable for use in van containers, all loading patterns tested were acceptable.

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